

AMORPHOUS GEL IN THE NAKHLITES: PRODUCT OF A RAPIDLY COOLED HYDROTHERMAL FLUID.

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Introduction: It has been demonstrated that the nakhlites' alteration assemblage includes an hydrated silicate gel. This is within the central part of veins, surrounded by smectite-(serpentine) and siderite in some cases [1]. High resolution TEM has shown the non crystalline nature of the gel [1]. It formed during rapid cooling in the latter stages of the hydrothermal event. In related work we show that the fluid was derived through dissolution of host nakhlite by a dilute brine [2]. Here we use more nakhlites to investigate the variation of composition of secondary minerals with depth and constrain the nature of the hydrothermal event.

Samples and Methods: We have analysed polished sections of Lafayette, NWA998, Governador Valadares, Nakhla, NWA817, Y000593, Y000749, Miller Range 03346, NWA5790 by SEM-EDX, FIB-SEM and TEM. EDX totals are normalised to 100% anhydrous.

Results: Most of the nakhlite veins are found to include the amorphous gel. No pure gel analyses have yet been made in NWA998 due to its small vein sizes or from NWA5790 and Y000749 due to their terrestrial weathering, which is shown for instance, by the presence of pure Ca carbonate and jarosite.

The average Mg/(Mg + total Fe) numbers of the gel are: Lafayette 0.38, GV 0.33, Nakhla 0.25, NWA817 0.22, Y000593 0.15, Miller Range 03346 0.14. Based on Fe K XANES analyses, the Fe³⁺/total Fe ratio of the gel is approximately 0.7-1.0 [3]. In Lafayette, the Fe/Si wt ratios of the gel 1.0-1.6 are in the same range as those of the phyllosilicate 1.0-1.6. Likewise the normalised Na₂O+K₂O contents of the Lafayette gel ≤0.8 wt% overlap those of the phyllosilicate ≤0.9 wt%. The highest gel Na₂O+K₂O contents seen so far ≤2.5 wt%, are in Nakhla. Al/Si wt ratios are similar in the phyllosilicate and gel ≤0.1.

Discussion: The variation of gel Mg# is not reflected in a parallel variation in the Mg# of the surrounding olivine. Nakhlite olivine has varying degrees of equilibration around ~Mg# 0.30. This suggests that the gel compositional fractionation is a function of variation in the composition of the fluid as it migrated up through the nakhlites rather than being controlled by the composition of the adjacent phases.

The gel Mg# compositions are mostly consistent with the predicted stratigraphy of the nakhlites which envisage NWA998 then Lafayette at the base and Miller Range 03346 near the top [4]. However, the low abundance of gel in NWA998 compared to Lafayette, which has a high abundance of secondary minerals and was closest to the fluid source, suggests that the nakhlites have preserved both lateral and vertical traces of the brine's passage and culmination. The presence of amorphous gel, with a composition similar to the Lafayette phyllosilicate, in most of the nakhlite veins demonstrates that the secondary assemblage formed in a short hydrothermal event, cooling too rapidly for phyllosilicate to continue crystallizing.

References: [1] Changela H.G. & Bridges J.C. 2010. MAPS, 45: 1847-1867. [2] Schwenzer S.P. & Bridges J.C. 2011 MAPS, this volume. [3] Hicks L.J. et al. 2011 MAPS, this volume. [4] Mikouchi T. et al. Abstract #1865, 37th Lunar & Planetary Science Conference.